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(71) Applicant: E-CHEN ENTERPRISE COMPANY [US/US]; 108 N. Ynez Avenue #128, Monterey Park, CA 91754 (US).

(71)(72) Applicant and Inventor: HSU, Chao, Fou [-/-]; 109 Lane 316, Dah Shuenn 3rd Road, Kaohsiung (TW).

(74) Agent: CHAN, Raymond, Y.; 516 San Luis Rey Road, Arcadia, CA 91007 (US).

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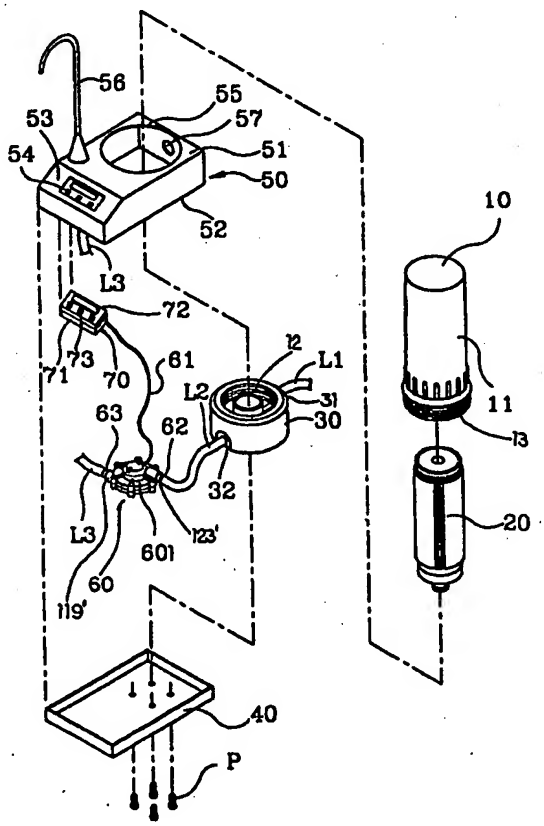
(54) Title: WATER PURIFICATION SYSTEM WITH INDICATING FLOWMETER

(57) Abstract

A water purification system with indicating flowmeter (60) includes a filter (10), a filter element (20), a filter mount (30), a base mount (40), a cover body (50), an indicating flowmeter (60), and a control device (70). The water purification system can calculate out the exact amount of the water filtered by the filter element (20) thereof through the indicating flowmeter (60) which provides a guideline for when the user or the maintainer needs to replace the filter element (20), so that the designated service life span of the filter element (20) can be maximized without sacrificing the quality of the produced water.



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Title of Invention

**Water Purification System With Indicating Flowmeter**

## Technical Field

The present invention relates to a water purification system with indicating flowmeter, and more particularly to a water purification system having a flowmeter for measuring the exact amount of water passed through the water filter and an indicator for indicating the amount of water in liter/gallon unit. The above data of exact amount of water filtered by the water filter not only can allow the user to know the updated condition of the filter element, but also can be use to indicate when the water filter should be replaced.

## Background Art

After the industrial revolution, pollution to the environment becomes a great threat to human daily life especially in the field of water pollution. Many factories and families do not act in due care in environment protection. Waste water and solid waste are dumped to nearby river, sewage, or ocean without proper water treatment. The waste water and solid waste not only pollute the surface water, but also eventually can find their way to the ground water and thus pollute all our drinking water resource. Other problems that degrade our water resource include the illegal dumping of garbage, and the animal waste of animal farm that are directly or indirectly dump into our river system.

As the houses and buildings in the community get older, the water pipes and the water storage tanks also aged. Most people don't check and replace their piping or water storage tanks within the time that is designed to last. So the older the communities are, the more deficiency on their drinking water quality. The drinking water from our water pipes may contain pesticide that is sunk in form of chemical element, and all kinds of impure substances that are built up over years in the water pipes or water storage tanks. Although the water sent into our water pipes needs to have a water purification process by the water company (usually by adding chlorine to kill all the bacteria within the water), the quality of water straight from the faucet is still not clean enough for most of the consumer to just drink directly from the faucet. Most families today install their own water purification systems to further purify the water from the water faucet in order to achieve higher water quality. The working principle of the water purification system is to utilize an activated carbon filter element positioned inside the water filter to absorb and filter different types of pesticide, chemicals, and floating particles in water, so that when the user pushes the

water outletting button, clean and read to drink water is available. However, it is important to periodically replace the activated carbon filter element in order to maintain the purity and quality of water.

But in rear life, after the installation of the water purification system in home, most people forgot the importance of replacing the activated carbon filter element. People merely know that the water purification system can provide clean and drinkable water instantly, but do not know when they have to maintain the water purification system, by replacing the filter element. Many people do not realize there is a need to replace the filter element of the water purification system until the producing water starts to have bad smell or bad taste. At this moment, the filter element of the water purification system is malfunctioned that it is entirely plugged by the impurity present in water. In fact when the activated carbon filter element is saturated with impurity, the ability to absorb and filter the impure substances is no longer functional. Moreover, the water purification system becomes the heaven for the bacteria to grow. The quality of water produced by such water purification system is even worse than the water directly from the faucet, that is very unhealthy to the human body.

## Disclosure of Invention

The main objective of the present invention is to provide a water purification system having an indicating flowmeter measuring the exact amount of water passed through a water filter and for indicating the amount of filtered water in liter/gallon unit. The above data of exact amount of water filtered by the water filter not only can allow the user to know the undated condition of the filter element, but also can be used to indicate when the water filter should be replaced to ensure the best quality of filtered water.

Another objective of the present invention is to provide a water purification system with indicating flowmeter which comprises a filter, a filter element, a filter mount, a base mount, a light induction flowmeter, and a control device. The water purification system of the present invention enables the user to selectively check the exact amount (liter/gallon) of water pass through the water filter so that the user or the water purification system maintainer can timely replace or clean the filter element according to such readable data. Therefore, the filter element will not be mistakenly replaced before the end of its life span and can ensure the quality of the water filtered by the water purification system.

Accordingly, a water purification system with indicating flowmeter of the present invention comprises a filter, a filter element, a filter mount, a base mount, a cover body, a light

induction flowmeter, and a control device. The water purification system with indicating flowmeter of the present invention can calculate out the exact amount of the water filtered by the filter element of the present invention by means of the light induction flowmeter, which provides a guideline of when the user or the maintainer needs to replace the filter element while the designated service life span of the filter element can be maximized without sacrificing the quality of the produced water.

## Brief Description of Drawings

Fig. 1 is an exploded perspective view of a water purification system with indicating flowmeter according to a preferred embodiment of the present invention.

Fig. 2 is a perspective view of the water purification system with indicating flowmeter according to the above preferred embodiment of the present invention.

Fig. 3 is a section end view of a base mount of the water purification system with indicating flowmeter according to the above preferred embodiment of the present invention.

Fig. 4 is an elevation view of the water purification system with indicating flowmeter in connection with water source according to the above preferred embodiment of the present invention.

Fig. 5 is a perspective view of the indicating flowmeter according to the above preferred embodiment of the present invention.

Fig. 6 is an exploded perspective view of the indicating flowmeter according to the above preferred embodiment of the present invention.

Fig. 7 is a sectional view of the indicating flowmeter according to the above preferred embodiment of the present invention.

Fig. 8 is a sectional view of a cover member of the indicating flowmeter according to the above preferred embodiment of the present invention, along line 4-4 as shown in Fig. 6.

Fig. 9 is another sectional view of the cover member of the indicating flowmeter according to the above preferred embodiment of the present invention, along line 5-5 as shown in Fig. 6.

Fig. 10 is a sectional view of a base seat of the indicating flowmeter according to the above preferred embodiment of the present invention, along line 6-6 as shown in Fig. 6.

Fig. 11 is another sectional view of the base seat of the indicating flowmeter according to the above preferred embodiment of the present invention, along line 7-7 as shown in Fig. 6.

Fig. 12 is a perspective view of the base seat of the indicating flowmeter according to the above preferred embodiment of the present invention.

Fig. 13 is a sectional view of a propeller wheel of the indicating flowmeter according to the above preferred embodiment of the present invention, along line 9-9 as shown in Fig. 6.

Fig. 14 is a sectional view of an induction rotator of the indicating flowmeter according to the above preferred embodiment of the present invention, along line 10-10 as shown in Fig. 6.

Fig. 15 is an elevation view of the induction rotator of the indicating flowmeter according to the above preferred embodiment of the present invention, illustrating the relationship between the induction rotator and a light emitting element and a light receptor element.

## Best Modes for Carrying Out the Invention

Referring to Fig. 1 to Fig. 3 of the drawings, a preferred embodiment of the present invention of a water purification system with indicating flowmeter is illustrated. The water purification system comprises a filter 10, a filter element 20, a filter mount 30, a base mount 40, a cover body 50, an indicating flowmeter 60, and a control device 70.

Referring to Figs. 1 to 4 of the drawings, the filter 10 is a hollow cylinder body with an opening 13 at a bottom end for receiving the filter element 20 therein. The filter element 20 can be an activated carbon filter element, a cork material filter element, or a half cork material and a half activated carbon filter element. At the bottom end of the filter 10 provides an outer thread portion 11 for engaging with an inner thread portion 12 provided on an inner wall of the filter mount 30. The filter mount 30 is affixed on the base mount 40 by a plurality of screws P, a water inlet opening 31 and a water outlet opening 32 are provided on two opposite sides of the filter mount 30 according to the preferred embodiment of the present invention. The water inlet opening 31 is connected to a first water tube L1 which is connected to a faucet switch 83 of a water faucet 80 (as shown in Fig. 4), thus it allow the water to enter the filter 10 and pass through the filter element for filtering. After filtering the filtered water would exit through the water outlet opening 32.

The cover body 50 which is mounted on the base mount 40, comprises a top portion 51, a bottom portion 52, an inclined front edge 53 provided on a front side of the cover body 50, and a back wall 58 perpendicularly provided between the top portion 51 and the bottom portion 52; in which on the top portion51, a circular central opening 55 is provided for the filter mount 30 to position therein. A water outlet tube 56 is extended upwardly from the top portion 51. A predetermined position on the back wall 58, a through hole 57 is provided thereon for allowing the first water tube L1 to pass therethrough.

The indicating flowmeter 60 comprises a light induction flowmeter 601, a guiding cable 61 which is connected to the control device 70 for transmitting detected signals, a water inlet 123', and a water outlet 119', in which the water inlet 123' is connected to the water outlet opening 32 of the filter mount 30 by a second water tube L2, and the water outlet 119' is connected to a bottom end of the water outlet tube 56 of the cover body 50 by a third water tube L3.

The control device 70 comprises a controlling circuit board 71 which is provided with controlling circuitry for receiving and computing the detected signals from the light induction flowmeter to indicate as exact amount of water flowing data, wherein an indicating panel 72

provided on the controlling circuit board 71 for displaying the exact amount of water flowing data, and a plurality of setting buttons 73. The control device 70 is positioned on a base surface of the inclined edge 53 of the cover body 50, and the plurality of setting buttons 73 and the indicating panel 72 are protruded from the button and indicating panel holes 54 respectively.

Referring to figs. 1 to 4 of the drawings, in order to function the water purification system with indicating flowmeter of the present invention, the user needs to equip a faucet switch 83, which can switch on and off of the faucet, with a water outlet of the faucet 80 (as shown in Fig. 4). The faucet switch 83 has an upper water outlet 81 connected to the first water tube L1 of the water inlet opening 31 of the filter mount 30 and a lower water outlet 82 allow the water to come out directly for normal usage. When the user wants to have purify drinkable water, the user needs to switch the faucet switch 83 to shut off the lower water outlet 82 and to enable water flowing through the upper water outlet 81, so that water would be forced to flow into the first water tube L1, through the water inlet opening 31 of the filter mount 30, to enter into the water purification system and be filtered by the filter element 20. The purify drinkable water after filtered is then sent into the light induction flowmeter 601 through the water inlet 123' of the light induction flowmeter 601 from the water outlet opening 32 of the filter mount 30 via the second water tube L2. After the light induction flowmeter 601 which is adapted for computing the amount of water passing through, the purify drinkable water is sent to the water outlet tube 56 from the water outlet 119' of the light induction flowmeter 601 via the third water tube L3. When the water passes through the light induction flowmeter 601, the light induction flowmeter 601 immediately sends out a detecting signal that is transmitted to the control device 70 through the guiding cable 61, and also displays the exact amount of water flow through the water purification system of the present invention on the indicating panel 72 of the controlling circuit board 71.

The light induction flowmeter 601 of the present invention comprises a flowing device 10', and a light induction unit 20', in which the flowing device 10' comprises a cover member 11', a base seat 12', and a magnetic propeller wheel 130'.

Referring to Figs. 6, 8 and 9, the cover member 11' has a plurality of ring appendices 111' on its periphery rim. Each ring appendix 111' has a thread hole Y1 (as shown in Fig. 7). An induction chamber 112' is formed on a central portion of a top surface of the cover member 11'. The cover member 11' has the water outlet 119' and an outlet channel 113' which ahs a top end connected to the water outlet 119' and is formed on a bottom surface of the cover member 11' (as shown in Fig. 9). A supporting axle 114' is upwardly protruded from a central area of a bottom surface of the induction chamber 112'. As shown in Figs. 7 and 8, the supporting axle 114' is a conical body defining a sharp supporting tip 1141'. A pair of confronting T-shaped grooves 115' and a pair of screw holes 116' are formed on a periphery wall of the induction chamber 112'

respectively (as shown in Fig. 6). A rotation axle 117' is downwardly protruded from a central area of a bottom side of the cover member 11'. As shown in Figs. 7 and 9, the rotation axle 117' is a conical body defining a sharp rotation tip 1171'. The supporting axle 114' and the rotation axle 117' are coaxially disposed on and under a thin central isolation wall 100' respectively, as shown in Figs. 7 and 8. The cover member 11' has a ring groove 118' provided near a periphery rim on the bottom side of the cover member 11', as shown in Figs. 7 and 9.

Referring to Figs. 5 and 7, the base seat 12' is tightly fixed on the bottom side of the cover member 11' with a bottom surface of the cover member 11' abutting to a top surface of the base seat 12'. Referring to Figs 6, 10, and 11, the base seat 12' has a plurality of fastening screw housings 121' on its periphery rim. Each fastening screw housing 121' has a threaded hole Y2 for a screw X1 to connect the cover member 11' by penetrating the corresponding threaded hole Y1 of the ring appendix 111' of the cover member 11' (as shown in Fig. 6). The top surface of the base seat 12' forms an indented water chamber 122'. The base seat 12' has a water inlet 123' and an inlet channel 126' formed between the water inlet 123' and the water chamber 122', as shown in Fig. 11. A bottom end of the outlet channel 113' is linked to the water chamber 122', so that the water inlet 123', the inlet channel 126', the water chamber 122', the outlet channel 113', and the water outlet 119' define a water flowing passage. As shown in Fig. 6, the base seat 12' has a ring guard 124' upwardly protruded from the top surface thereof. A ring seal O' is placed around the outside wall of the ring guard 124' of the base seat 12' and within the ring groove 118' of the cover member 11', as shown in Fig. 7. Thus, the water chamber 122' and the induction chamber 112' are sealed and isolated. A bottom surface of the water chamber 122' has an axial indention 125', which is formed coaxially with the rotation axle 117'.

Referring to Fig. 12, a bottom surface of the base seat 12' has a predetermined number of L-shaped positioning ribs 127'. Each of the two sides of each positioning rib 127' is parallel to a side of a neighboring positioning rib 127'. At a corner of each positioning rib 127' has a protrusion 128' protruding toward a center of the base seat 12'. A predetermined distance is defined between the protrusion 128' and the bottom surface of the base seat 12'.

Referring to Figs. 6, 7 and 13, the magnetic propeller wheel 130' comprises a propeller wheel 13', which is a circular body 13a', and a plurality of curved propeller blades 13b' extended radially from the circular body 13a'. A ring-shaped magnetic element 131' is coaxially embedded on a top side of the propeller wheel 13'. Referring to Figs. 7 and 13, a central axial recess 132' and a propeller axle 133' are coaxially indented at a center of a top side of propeller wheel 13' and protruded downwardly from a center of a bottom side of the propeller wheel 13' respectively. The propeller wheel 13' is situated and supported in the water chamber 122' of the base seat 12' in rotatable manner that, the rotation axle 117' of the cover member 11' is fitted into the central

axial recess 132' and the propeller axle 133' is fitted into the axial indention 125' located ~~in~~ the center of the water chamber 122' of the base seat 12', as shown in Fig. 7. Since the contact area between the axial recess 132' and the rotation axle, and the contact area between the propeller axle 133' of the propeller wheel 13' and the axial indention 125', are limited to their contacting points only, the friction therebetween is minimized to facilitate the rotation motion of the propeller wheel 13'.

Referring to Fig. 6, the light induction unit 20' comprises a magnetic induction rotator 210', a light emitting element 22', a light receptor element 23', and a top lid 24'.

Referring to Figs. 6 and 7, the magnetic induction rotator 210' comprises an induction rotator 21' and a magnetic ring 212'. The induction rotator 21' is a cylindrical body situated in the induction chamber 112' of the cover member 11' of the flowing device 10'. A bottom portion of the induction rotator 21' forms an enlarged circular basal rim 215'. Referring to figs. 6, 7 and 14, the induction rotator 21' has a conical axial rotating cavity 211' indented at a bottom end thereof for fitting onto the supporting axle 114' located at the bottom of the induction chamber 112'. Since the contact area between the induction rotator 21' and the supporting axle 114' is limited to a sharp supporting tip 1141' of the supporting axle 114', the friction therebetween is minimized. In such manner, the induction rotator 21' is capable of rotating along the supporting axle 114' while only a relative small induction rotating force is applied to the induction rotator 21'.

A magnetic ring 212' is encased on top of the basal rim 215' in such manner that, the magnetic ring 212' is coaxially confronted with the ring-shaped magnetic element 131' which is embedded on the propeller wheel 13'. Furthermore, a bottom side of the magnetic ring 212' and a top side of the ring-shaped magnetic element 131' are arranged with opposite magnetic poles to achieve magnetic induction. Thus, the rotation of the propeller wheel 13' driven by water flow through the water chamber 122' may induce the induction rotator 21' to rotate simultaneously. The induction rotator 21' has at least a transverse rotator through slot 213' extending form on e side to another side of the induction rotator 21'. A top end of the induction rotator 21' forms a circular tip 214'.

Referring to Figs. 6 and 7, an infrared beam emitting member can be sued as the light emitting element 22' and an infrared bean detector can be used as the light receptor element 23'. The light emitting element 22' and the light receptor element 23' are respectively mounted in the corresponding opposite T-shaped grooves 115' on the periphery wall of the induction chamber 112', so that the rotator through slot 213' formed at a predetermined height can be aligned with the light emitting element 22' and the light receptor element 23'. Accordingly, the infrared beam

emitted from the light emitting element 22' can pass through the rotator through slot 213' and be received by the light receptor element 23' per every rotation of the induction rotator 21', as shown in Fig. 15. Since the inductor rotator 21' may has one or more rotator through slots 213' presented in the middle part thereof, the continuous infrared beam emitted by the light emitting element 22' is blocked off intermittently by the induction rotator 21' during the inductor rotator 21' rotates.

The light receptor element 23' therefore converts each intermittent light into an electrical signal. Basically, the light receptor element 23' therefore receives two kinds of light sensor signals, i.e. light penetration and no light penetration. Such signals are transmitted to an usual external electronic counting circuit system (not shown). An accurate quantity of flow can be calculated according to the equation:

Quantity of Flow (Q) = Cross Sectional Area (A) X Flow Velocity (V)

Referring to Figs. 5, 6 and 7, the top lid 24' has a pair of holes 241' on its top. Two screws X2 are screwed through the holes 241' into the screw holes 116' of the induction chamber 112' for mounting the top lid 24' in position to cover the induction chamber 112' of the cover member 11'. A bottom conical axial mounting recess 242' is formed, in a center of the bottom side of the top lid 24' and coaxially with the supporting axle 114' of the cover member 11. The circular tip 214' of the induction rotator 21' is fitted into the bottom axial mounting recess 242' of the top lid 24'. At least two wire grooves 243' are formed in appropriate positions in the rim of the top lid 24' enabling the electrical wires of the light emitting element 22' and the light receptor element 23' to pass through.

It is worth to mention that the user can input the designated service life span allowable for the filter element 20 in the control device 70 through the setting button 73 (usually the manufacturer of the filter element 20 will have information on the designated life span of each type of the filter element 20 in liter/gallon unit) so that after a period of usage of the water purification system of the present invention, when the water flow amount passed through the filter element 20 of the water purification system is surpassed the designated service life span allowable, an alarm will sound, or a pre-recorded massage will play to notify the user that the filter element 20 need to be replaced.

Accordingly, the water purification system with indicating flowmeter of the present invention can accomplish the expected result and provide the most scientific, and economical way

to replace the filter element of the water purification system of the present invention without sacrificing the quality of produced water.

I Claim:

1. A water purification system with indicating flowmeter, comprising a filter, a filter element, a filter mount, a base mount, a cover body, an indicating flowmeter, and a control device, in which

said filter being a hollow cylinder body having an opening at a bottom end for receiving said filter element therein, at said bottom end of said filter providing an outer thread portion for engaging with an inner thread portion provided on an inner wall of said filter mount;

said filter mount being affixed on said base mount, a water inlet opening and a water outlet opening being provided on two opposite sides of said filter mount, said water inlet opening being connected to a first water tube which is connected to faucet switch of a water faucet, so as to allow water to enter said filter and pass through said filter element for filtering, and to exit through said water outlet opening after filtering;

said cover body which is mounted on the base mount, comprising a top portion, a bottom portion, an inclined front edge provided on a front side of said cover body, and a back wall perpendicularly provided between said top portion and said bottom portion, wherein said top portion has a circular central opening for mounting said filter in position therein and a water outlet tube extended upwardly thereon, a predetermined position on said back wall having a through hole provided thereon for allowing said first water tube to pass therethrough;

said indicating flowmeter comprising a light induction flowmeter, a guiding cable which is connected between said light induction flowmeter and said control device for transmitting detected signals, a water inlet, and a water outlet, wherein said water inlet is connected to said water outlet opening of said filter mount by a second water tube, and said water outlet is connected to a bottom end of said water outlet tube of said cover body by a third water tube; and

said control device comprising a controlling circuit board which provides with a controlling circuit for receiving and computing said detected signals from said light induction flowmeter to indicate as exact amount of water flowing data, an indicating panel provided on said circuit board for displaying said exact amount of water flowing data, and a plurality of setting buttons, said control device being positioned on a base surface of said inclined front edge of said cover body, and said setting buttons and said indicating panel being exploded on said inclined front edge.

2. A water purification system with indicating flowmeter, as recited in claim 1, wherein said filter element comprises an activated carbon filter element.

3. A water purification system with indicating flowmeter, as recited in claim 1, wherein said filter element comprises a cork material filter element.

4. A water purification system with indicating flowmeter, as recited in claim 1, wherein said filter element comprises a half cork material and a half activated carbon filter element.

5. A water purification system with indicating flowmeter, as recited in claim 1, wherein said light induction flowmeter comprises:

a flowing device having a water chamber and an induction chamber proximately formed therein, in which said water chamber has a water inlet and a water outlet to define a water flowing passage therebetween, so as to enable a water flow flowing through said water flowing passage inside said water chamber by entering through said water inlet and outputting through said water outlet, said water chamber being isolated with said induction chamber to prevent said water flow inside said water chamber from entering said induction chamber;

a magnetic propeller wheel rotatably disposed in said water chamber, wherein said magnetic propeller wheel is capable of being driven to rotate by said water flow inside said water chamber;

a light induction unit which comprises a magnetic induction rotator disposed coaxially with said magnetic propeller wheel and inside said induction chamber of said flowing device in rotatable manner, said induction rotator having at least a transverse rotator through slot extending from one side to another side of said induction rotator; and

a light emitting element and a light receptor element mounted respectively on two opposite sides of said induction chamber, wherein said rotator through slot of said induction rotator is capable of aligning with said light emitting element and said light receptor element, so that a light beam emitted from said light emitting element passes through said rotator through slot of said induction rotator and is received by said light receptor element per every rotation of said induction rotator, said magnetic induction rotator being driven by said rotating magnetic propeller wheel to rotate simultaneously, thereby said rotating magnetic induction rotator intermittently blocks off said light beam emitted continuously by said light emitting element and said light receptor element receives an intermittent light per each rotation of said magnetic induction rotator, and that a frequency of reception of said intermittent light by said light receptor element is

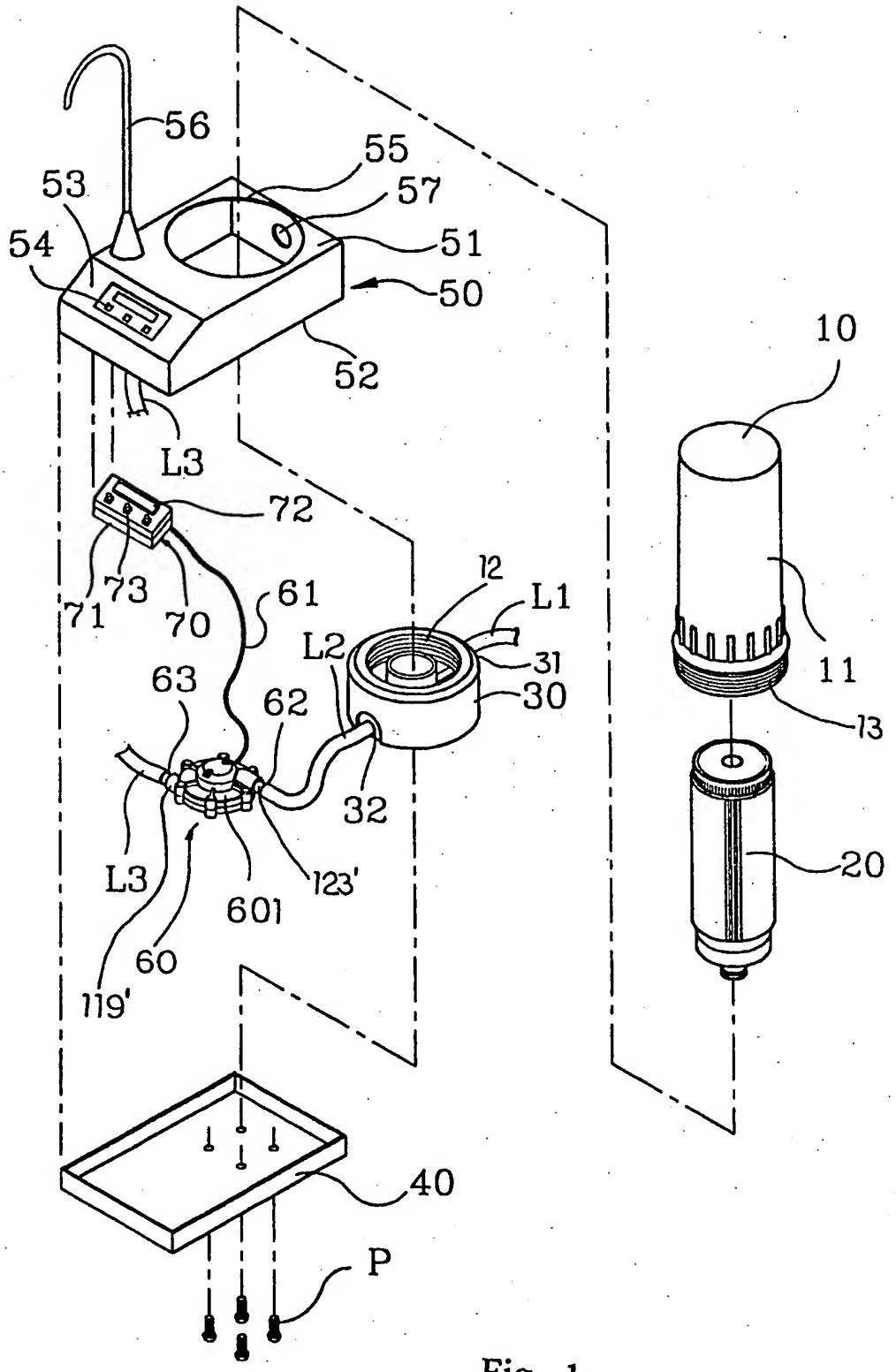
proportional to a water flow rate of said water flow inside said water chamber, and that said light receptor element converts said intermittent light into electrical signals as said detected signals.

6. A water purification system with indicating flowmeter, as recited in claim 5, wherein said magnetic propeller wheel comprises a propeller wheel and a magnetic element which is mounted on a first side of said propeller wheel to enable said propeller wheel having magnetic feature and said magnetic induction rotator comprises an induction rotator and a magnetic ring which is mounted on a bottom portion of said induction rotator to enable said induction rotator having magnetic feature, wherein said magnetic ring is confronted with said magnetic element on said propeller wheel within said water chamber and that a bottom side of said magnetic ring and a top side of said magnetic element are arranged with opposite magnetic poles to achieve magnetic induction, thereby the rotation of said propeller wheel driven by water flow through said water chamber induces said induction rotator to rotate simultaneously.

7. A water purification system with indicating flowmeter, as recited in claim 5, wherein a thin isolation wall is formed between said water chamber and said induction chamber, a first surface of said isolation wall which located in said induction chamber protruding a supporting axle and a bottom end of said induction rotator forming a rotating cavity for fitting into said supporting axle so as to support said induction rotator in rotary position.

8. A water purification system with indicating flowmeter, as recited in claim 6, wherein a second surface of said isolation wall which located in said water chamber coaxially protrudes a rotation axle, a bottom surface of said water chamber forms an axial indention which is coaxial with said supporting axle, and the center of the first side of said propeller wheel forms a central axial recess for fitting onto said rotation axle and the center of a second side of said propeller wheel protrudes a propeller axle for fitting into said axial indention so as to hold said propeller wheel in rotary position

9. A water purification system with indicating flowmeter, as recited in claim 7, wherein a second surface of said isolation wall which located in said water chamber coaxially protrudes a rotation axle, a bottom surface of said water chamber forms an axial indention which is coaxial with said supporting axle, and the center of the first side of said propeller wheel forms a central axial recess for fitting onto said rotation axle and the center of a second side of said propeller wheel protrudes a propeller axle for fitting into said axial indention so as to hold said propeller wheel in rotary position.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P

Fig. 1

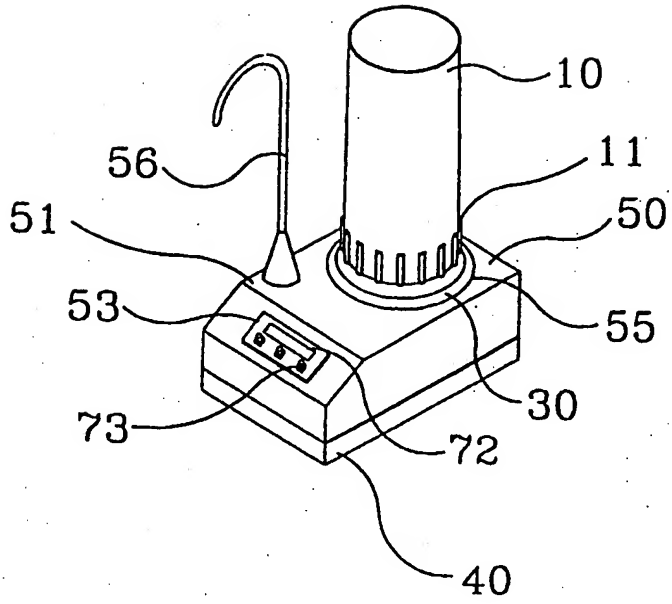


Fig. 2

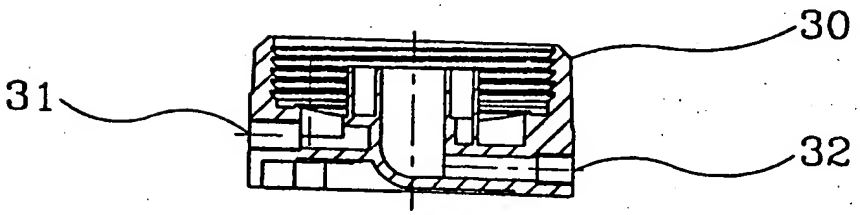


Fig. 3

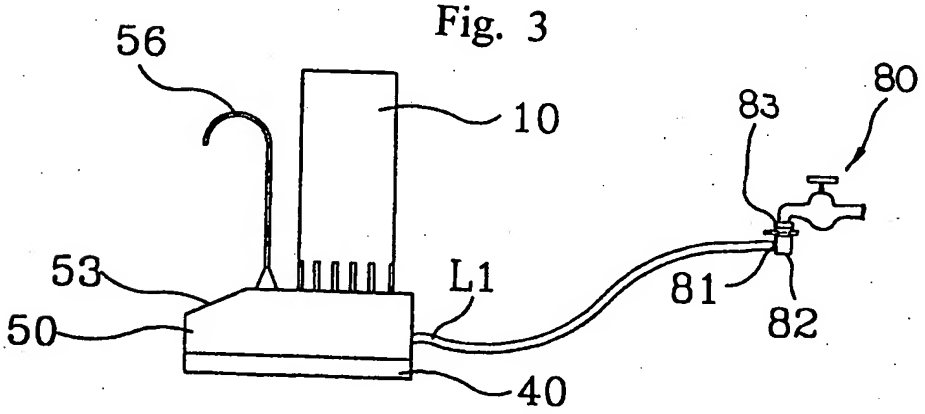


Fig. 4

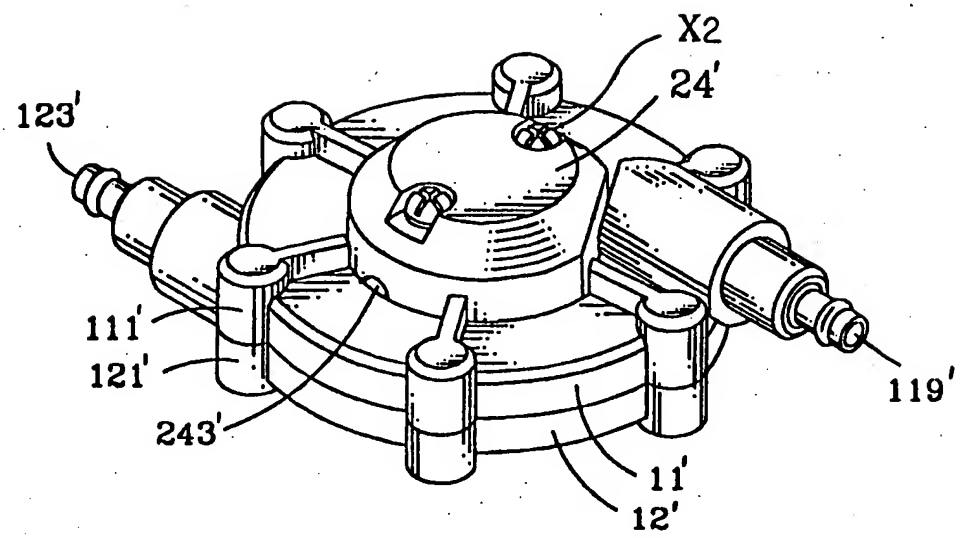
X2
24'
123'
111'
121'
243'
119'
11'
12'

Fig. 5

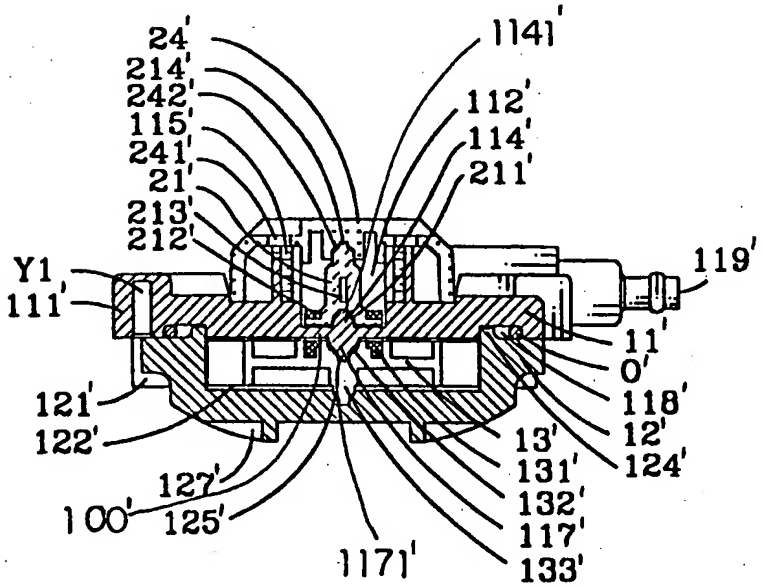
24'
214'
242'
115'
241'
21'
213'
212'
1141'
112'
114'
211'
Y1
111'
119'
11'
0'
118'
12'
124'
121'
122'
13'
131'
132'
117'
133'
127'
100'
125'
1171'

Fig. 7

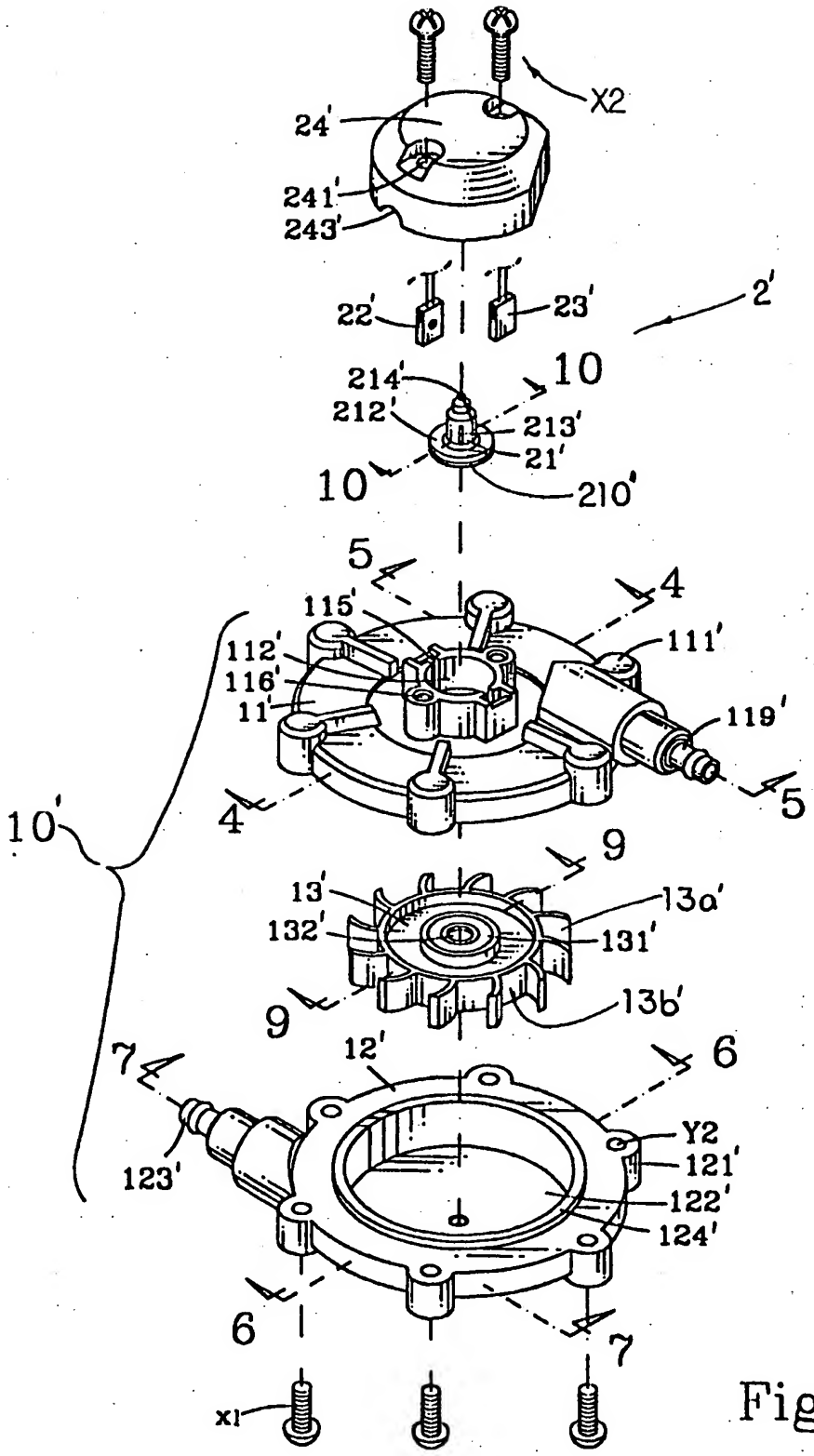
X2
24'
241'
243'
22'
23'
2'
214'
10
212'
213'
21'
10
210'
5
4
115'
111'
112'
116'
11'
119'
4
5
10'
9
13'
13a'
132'
131'
9
13b'
7
12'
6
Y2
123'
121'
122'
124'
6
7
x1

Fig. 6

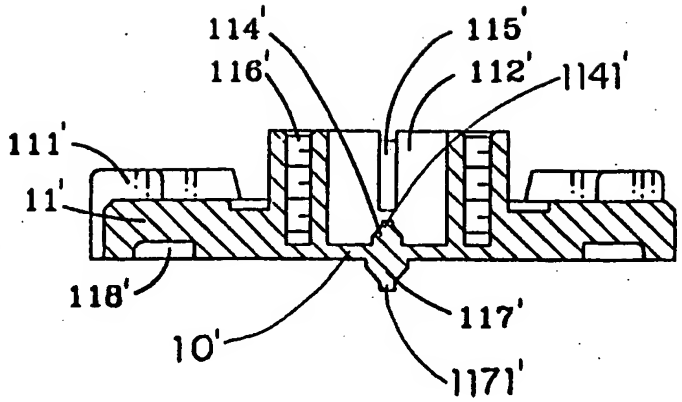


Fig. 8

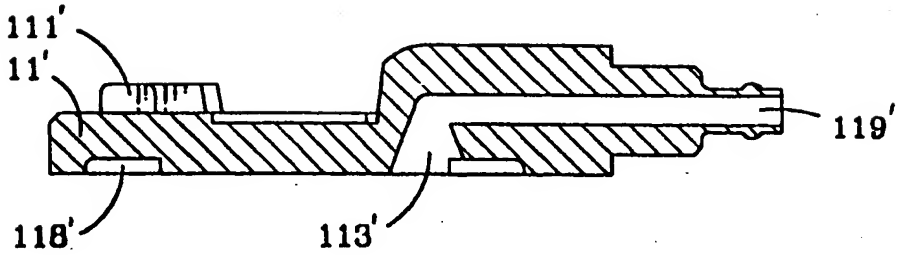


Fig. 9

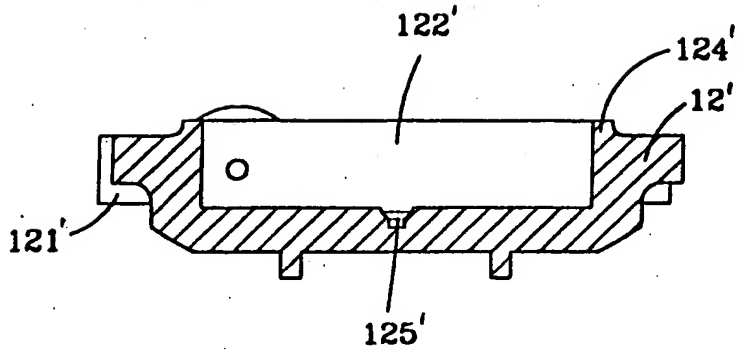


Fig. 10

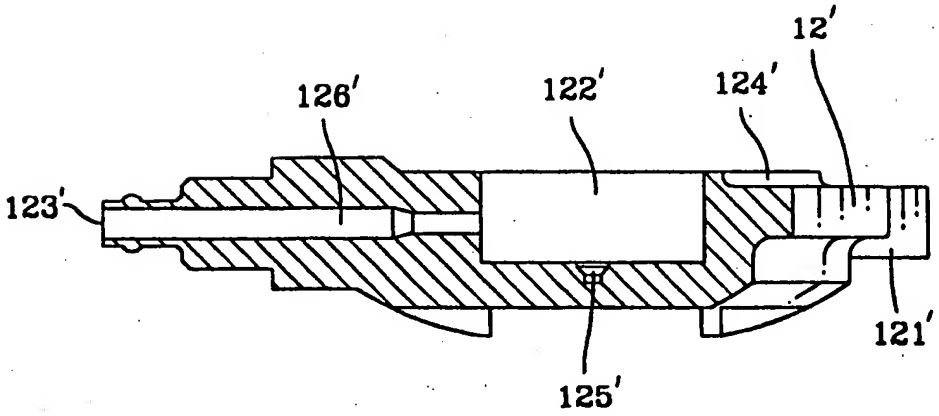


Fig. 11

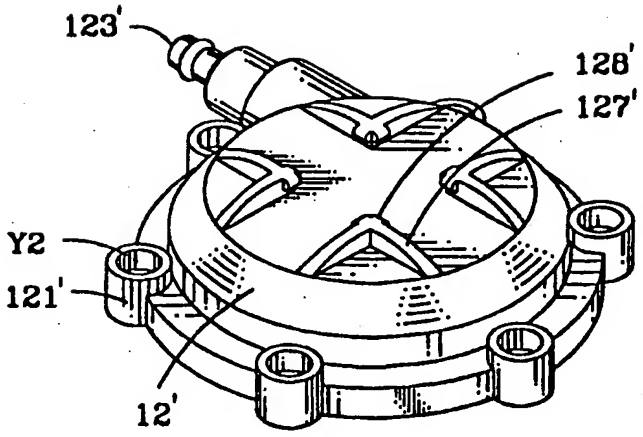


Fig. 12

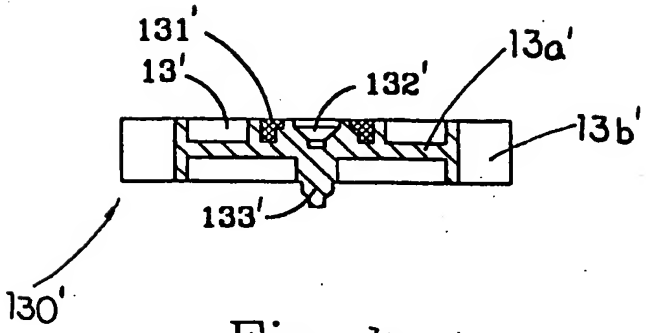


Fig. 13

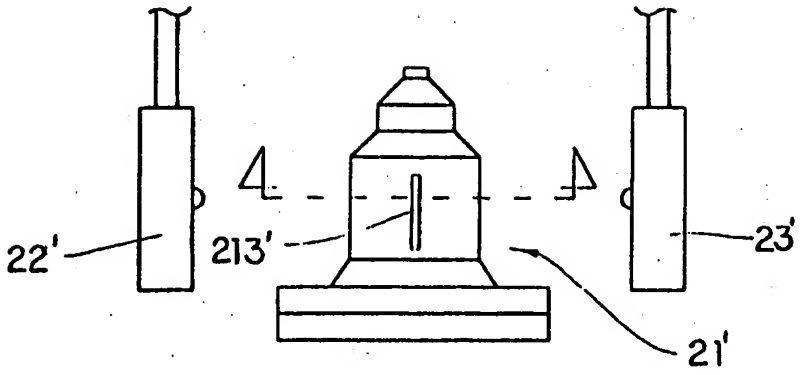


Fig. 15

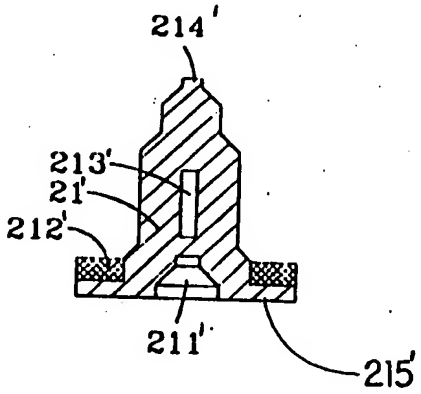


Fig. 14

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/24084

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :B01D 17/12
US CL :210/87
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 210/87, 88, 89, 94, 100, 282, 443, 449, 691, 739, 745; 73/861.77, 861.78, 861.79, 861.86, 861.87

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US 5,622,618 A (BRANE et al) 22 April 1997 (22-04-97), see entire document. | 1-9 |
| Y | US 5,542,302 A (MCMILLAN et al) 06 August 1996 (06-08-96), see entire document. | 7-9 |
| Y | US 5,540,107 A (SILVERMAN et al) 30 July 1996 (30-07-96), see entire document. | 1-9 |
| Y | US 4,681,677 A (KUH et al) 21 July 1987 (21-07-87), see entire document. | 1-9 |
| Y | US 4,195,522 A (ANDERSON et al) 01 April 1980 (01-04-80), see entire document. | 1-9 |
| Y | US 4,178,438 A (HAASE et al) 11 December 1979 (11-12-79), see entire document. | 3 and 4 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

| | | | |
|---|---|---|---|
| * | Special categories of cited documents: | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
| "A" | document defining the general state of the art which is not considered to be of particular relevance | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| "E" | earlier document published on or after the international filing date | "Y" | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "L" | document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "&" | document member of the same patent family |
| "O" | document referring to an oral disclosure, use, exhibition or other means | | |
| "P" | document published prior to the international filing date but later than the priority date claimed | | |

Date of the actual completion of the international search
17 JUNE 1998

Date of mailing of the international search report
06 JUL 1998

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
JOSEPH W. DRODGE
Telephone No. (703) 308-0651

Form PCT/ISA/210 (second sheet)(July 1992)*